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ABSTRACT

This issues paper was prepared by a task force convened by the Mathematical Sciences Education Board to explore the feasibility of assembling and disseminating source materials for mathematics departments and individual faculty members at the college level seeking to better document their educational growth and effectiveness over time. Four possible directions for action are offered in reference to faculty reward structures: broadening the definition of professional involvement to include work on educationally significant problems; making the setting and achieving of departmental objectives the collective responsibility of all members of a department; supporting faculty throughout their proefssional careers as their areas of interest change; and creating and supporting natural communities of interest. Four suggested tools to document growth and effectiveness are: professional briefs, teaching portfolios, departmental portraits, and case studies. Contains 23 references. (MKR)

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Teaching Growth and Effectiveness: An Issues Paper

Mathematical Sciences Education Board

National Research Council

ED 393 673

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PREFACE

The 1991 National Research Council publication *Moving Beyond Myths: Revitalizing Undergraduate Mathematics* describes the centrality of the undergraduate mathematics program in shaping the reasoning skills of future teachers, scientists, engineers, and leaders from many professions. It can be argued that the best route for improving all students' mathematical knowledge and skills is through an improved undergraduate mathematics program. Improving mathematics education in colleges and universities will involve changing both *what* is taught in collegiate mathematics and *how* it is taught. Making these changes will require increased involvement of faculty not only in undergraduate teaching but in a wide range of related educational activities as well.

This Issues Paper was prepared by a task force convened by the Mathematical Sciences Education Board to explore the feasibility of assembling and disseminating source materials for mathematics departments and individual faculty members seeking to better document their educational growth and effectiveness over time. The eight-member *Task Force on Teaching Growth and Effectiveness* included mathematics faculty, college and university administrators, and a representative of a higher-education association. Task Force members were asked to synthesize their knowledge about (1) critical issues in understanding what constitutes faculty growth and effectiveness in undergraduate mathematics education; (2) the kinds of mechanisms for promoting faculty involvement in educational activities that seem to be effective and how they might differ from institution to institution; and (3) existing models for documenting a faculty member's or a department's effectiveness, including those from other disciplines that can be adapted for use by the mathematics community. The purpose of this paper is to stimulate discussion among faculty within their departments, to contribute to dialogue within professional societies, and eventually to promote consensus on this very important issue.

The issues raised by the Task Force are posed as two questions, one asking how the faculty rewards structure can be changed to reflect the importance of work in mathematics education and one inquiring about the kinds of tools available to faculty who want to document their growth and effectiveness in undergraduate mathematics education.

Four possible directions for action are offered in response to the first question:

- Option A: Broaden the definition of professional involvement to include work on educationally significant problems.
- Option B: Make the setting and achieving of departmental objectives the collective responsibility of all members of a department.

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- Option C: Support faculty throughout their professional careers as their areas of interest change.
- Option D: Create and support natural communities of interest.

Four tools that mathematics faculty and departments can use to document their growth and effectiveness in undergraduate mathematics education are described in response to the second question:

- Option A: Professional Briefs
- Option B: Teaching Portfolios
- Option C: Departmental Portraits
- Option D: Case Studies

We offer this Issues Paper to promote dialogue on faculty roles in strengthening undergraduate mathematics education and as a catalyst for debate and action. We invite responses and commentary. Response forms are provided at the end of the discussion about each issue. You can use the forms if you wish; if you'd rather use e-mail, please provide your comments in a format similar to that on the response forms. Written responses can be sent to Susan Forman, Director of College & University Programs, Mathematical Sciences Education Board, 2101 Constitution Ave., NW, HA 476, Washington, DC 20418; FAX to Susan Forman at (202) 334-1453; or e-mail to sforman@nas.edu.

Harvey B. Keynes, *Chairman*
MSEB Panel on Higher Education
January, 1994

MSEB TASK FORCE ON UNDERGRADUATE TEACHING GROWTH AND EFFECTIVENESS

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INTRODUCTION

Higher education is in a period of intense change driven by both internal and external forces. The nation is looking to its colleges and universities to provide the human and intellectual capital needed to help restore our social and economic vitality. At the same time, the government is about to undertake a review of federal science policy, which will include a reassessment of the role of university research in the post-cold-war era.

Congressman George Brown signals the transitions to the new era by calling on scientists to welcome change

in their political responsibilities and professional standards of excellence: "Scientific traditions cannot be perceived as conflicting with, or superseding, the test of political and economic necessity, nor can they be justified through appeals to myth and privilege." [Brown, 1993]

Not only is the research mission of universities being scrutinized, but colleges and universities are also being called upon to strengthen their commitment to education, particular undergraduate education. Congressman Rick Boucher, Chairman of the House Subcommittee on Science, outlined a new agenda for institutions of higher education:

> *Universities must do a better job of explaining-- to themselves and to the public--exactly what it is they contribute to society. They must demonstrate the effectiveness of their research and teaching. ... Sustainable universities will be those that examine their focus and missions in light of the challenges created by changing conditions and respond in ways that clearly demonstrate that they provide value to our society.* [Boucher, 1993]

Representative Boucher's words have dramatic implications for faculty members' educational work. They suggest not only a resetting of the balance among research, teaching and service, but a reconceptualization of their meanings and interrelations. This reconceptualization of responsible educational practice must respect changing societal needs and accountability requirements while it builds on our traditions of excellence and intellectual autonomy.

These calls for change from Congress are reflected by increasing signs of disquiet among many other friends of higher education. For example, a recent open letter from Wingspread, "An American Imperative: Higher Expectations for Higher Education," challenges higher education to re-evaluate its contributions to American society. [Brock, 1993]

One consequence of these calls to rethink the role of colleges and universities is the need for faculty to demonstrate the effectiveness of their educational work in a time of change in higher education. The principal goal of this paper is to gather input from faculty members concerning their reactions to possible options for documenting growth and effectiveness in undergraduate mathematics education.

MATHEMATICS EDUCATION REFORM

Indeed, the debate about the goals and means of educational reform is well underway in the mathematics community. The 1989 National Research Council publication Everybody Counts set the stage for reform in mathematics education by calling for the community to unite behind an effort to teach more mathematics to all students. The National Council of Teachers of Mathematics' *Curriculum and Evaluation Standards* (1989) and *Professional Standards* (1991) provided a framework for change in K-12 mathematics education.

The Mathematical Science Education Board (MSEB), created by the National Research Council (NRC) in 1985, is both a product of and a catalyst for efforts to revamp mathematics education. The NRC's 1991 publication *Moving Beyond Myths: Revitalizing Undergraduate Mathematics* draws attention to needed changes at the college and university level and discusses how those changes might be accomplished. These reports acknowledge the unique role that undergraduate mathematics plays, not only for future scientific workers but for all employees in a technology-rich society. They also point to the centrality of undergraduate mathematics education in strengthening the preparation of prospective teachers of mathematics at all levels. Thus, it can be argued that the best route for improving all students' mathematical knowledge and skills is through an improved undergraduate mathematics program. "Undergraduate mathematics is the linchpin of mathematics education. ... No reform of mathematics education is possible unless it begins with revitalization of undergraduate mathematics in both curriculum and teaching style." [NRC, 1991]

Improving undergraduate mathematics will require the participation of the entire higher education mathematics community which will, in turn, require changes in the kinds of activities that are valued and rewarded. In recognition of this fact, the Joint Policy Board for Mathematics (JPBM) undertook a study of the professional recognition and rewards system through site visits at diverse institutions of higher education and non-academic institutions and questionnaires to faculty members and chairs of mathematical sciences departments. The findings of the JPBM Committee on Faculty Recognition and Rewards confirm the general belief that the system is not working well since they found that there were discrepancies between the perceptions of faculty, chairs and deans about how the rewards system is working. [Moore, 1994]

A VIEW FROM THE PROFESSION

As a consequence of these diverse voices advocating reform, consensus is beginning to emerge among the leadership of the undergraduate mathematics community about the need to change both what is taught and the way it is taught. With the support of the National Science Foundation and other funders, efforts are being made to enlist the involvement of all faculty at post-secondary institutions around the country to consider the direction of reform and to implement appropriate changes. Yet, controversy remains about how much effort college and university faculty should be devoting to educational activities, about how such effort is to be evaluated, and about how education fits into the faculty reward system.

Traditionally, faculty have devoted their efforts to three areas: research, teaching, and service (to the institution, the community and the profession). At many post-secondary institutions, particularly four-year colleges and universities, the professional emphasis has been on discipline-based research. Teaching has been largely confined to individual work in the classroom, and being a good teacher has been less highly valued than being a good researcher. Service is the least regarded aspect of professional life.

The issue of faculty time is taken up by Ernest L. Boyer in his widely praised volume Scholarship Revisited: Priorities of the Professoriate. Boyer also explores the question of which activities of the professoriate are most highly valued, pointing to the national concern about how well students are being served. "After all, it's futile to talk about improving the quality of teaching if, in the end, faculty are not given recognition for the time they spend with students." [Boyer, 1990]

Evidence of the academy's concern about teaching was expressed in the 1992 report to the National Science Foundation (NSF) by the Presidential Young Investigators [NSF, 1992], who said that the NSF must:

- Encourage and reward teaching excellence, instructional scholarship, and public service as well as research.
- Increase substantially resources for instructional innovation and curriculum renewal, especially for undergraduate education.
- Assume primary responsibility for public understanding of science and technology, principally through high quality precollege teacher preparation and lower division undergraduate instruction.
- Assure adequate career participation in engineering, mathematics, and the sciences by all segments of society, particularly careers as precollege or college faculty.
- Encourage the development of inquiry-oriented learning environments and technology-based instruction at all educational levels. The position of the professional societies on these issues was expressed in 1993 when the two organizations whose primary concern is undergraduate mathematics education, the Mathematical Association of America (MAA) and the American Mathematical Association of Two-Year Colleges (AMATYC), published guidelines intended to strengthen undergraduate mathematics programs and departments. These guidelines include the following recommendations:

    - Departments should provide opportunities for improving faculty teaching expertise, including development of a variety of teaching strategies.
    - All full-time faculty should engage in sustained scholarship, broadly defined to include discovery, integration, application of knowledge, and scholarship related to teaching.
    - Departments and their institutions should, through appropriate reward structures, encourage, recognize, and value the diverse nature of faculty scholarship that is directly related to the department's mission and goals.

It is widely agreed that to achieve these goals, faculty and administrators in our nation's colleges and universities must think carefully about how the full range of faculty members' professional activities are regarded and rewarded.

The remainder of this paper addresses two issues: (1) ways in which faculty work in undergraduate mathematics education can be discussed and documented in order to affect changes in the collegiate rewards system and (2) tools that faculty can use to discuss and document their growth and effectiveness in undergraduate mathematics education.

TRANSFORMING REWARDS

The forthcoming study by the Joint Policy Board on Mathematics Committee on Professional Recognition and Rewards recommends that there is an urgent need for departments of mathematical sciences to change the faculty rewards and recognition system to include the full range of activities required to meet departmental objectives and support the institutional mission [Moore, 1994]. This sets the stage for discussion of the first issue.

Issue #1: ***How can the collegiate rewards system be transformed into one in which work in undergraduate mathematics education is highly valued?***

Transforming the collegiate rewards system will require that faculty be able to demonstrate their growth and effectiveness as educators in ways that parallel methods used to demonstrate research abilities and accomplishments. In Scholarship Revisited: *Priorities of the Professoriate*, Boyer confirms that "The question of how to evaluate teaching remains a mare's nest of controversy. The problem relates not only to procedures but also to the weight assigned to the endeavor. ... For teaching to be considered equal to research, it must be vigorously assessed, using criteria that we recognize within the academy, not just in a single institution." [Boyer, 1990]

The MSEB Task Force identified four areas for consideration by undergraduate mathematics faculty and departments in order to address the dilemma posed by Boyer. The first is to define professional involvement broadly to include work on educationally significant problems. The second is to develop the concept of "collective responsibility" of members of a department in their response to serving the institutional mission and meeting objectives of the department's mathematics program. The third issue is that as faculty members move through their professional careers and as their interests change, their institutional responsibilities and roles need to be reevaluated and supported. The last is the need for "natural communities" in which discussions about educational issues can take place, professional peer review can become meaningful, and plans for action can be developed. Natural communities can provide a forum in which teaching becomes a public activity, a necessary condition if teaching is to be effectively assessed.

Option A: ***Broaden the definition of professional involvement to include work on educationally significant problems.***

Boyer's expanded view of professional responsibilities includes advancing knowledge, synthesizing and integrating knowledge, applying knowledge, and representing knowledge through teaching. The first part of Boyer's definition has been widely accepted by the higher education mathematics community, for even those who do not, themselves, engage in pure or applied research appreciate its value and understand the professional tradition of such work. The other three components provide a platform from which to examine what it means for mathematicians and mathematics educators to work on educationally significant problems. All are appropriate for discussion of faculties' professional responsibilities to students.

Work on educationally significant problems goes beyond what a faculty member does in a classroom and might include:

- Curriculum and program development
- Integrating new areas of mathematics
- Creating student-centered advisement procedures
- Mentoring junior faculty and graduate students
- Developing alternative instructional strategies
- Implementing the use of technology
- Planning strategies to increase access for all students
- Research in all aspects of mathematics education

Option B: ***Make the setting and achieving of departmental objectives the collective responsibility of all members of a department.***

Common practice places most, if not all, responsibility for meeting departmental objectives on the individual efforts of faculty members in their classroom instruction. An alternative view is to acknowledge that the success of an educational program and responsibility for its outcomes depend as much on departmental and institutional behavior as on that of individuals. This new concept of *collective responsibility* for reforming mathematics education has a striking potential to stimulate discussion and thereby improve teaching in the

college and university mathematics departments.

In a paper about implementation of collective accountability prepared for an American Association for Higher Education (AAHE) conference on incentives and rewards, Ernest Lynton argues that "the definition of the collective responsibilities and the assessment of collective performance requires a far more systematic as well as a more participatory process than currently exists in departmental resource allocations." He further suggests that "the collective rewards (as well as possible sanctions) resulting from the assessment should have an impact on the working conditions of individual members of the unit so as to trigger their self-interest in the achievement of collective goals." [Lynton, 1993]

At most colleges and universities, the principal instructional unit is the department, be it a mathematics (or a mathematics/computer science/statistics) department or a developmental studies department. Establishing consensus within a department about meeting its collective responsibility would require negotiation among the members to define the scope and character of individual contributions to meeting the department's goals. An inherent value in directly linking individual contributions to a department's collective responsibility is the flexibility it provides to exploit to the maximum extent the personal strengths and interests of each member of that department. When negotiations to reach consensus occur periodically, they can provide faculty the flexibility to make contributions to their institution's mathematics program in different ways at different times in their careers. Furthermore, in the public setting of determining how to satisfy a department's educational and research needs, individual faculty can make their priorities known to their colleagues. These discussions can provide an opportunity to come to terms with the duality between their own work and that of the department. Thus the negotiation process itself can becomes a vehicle for reform: the public nature of the discussion sanctions the necessary changes.

If responsibility for reforming mathematics education is to extend beyond the walls of individual classrooms, departments and academic institutions, it would require the mathematics community as a whole to take an active role in quality improvement. To be effective, new approaches to teaching and assessment would require collaboration between and among faculty, administrators, and other players in the undergraduate education enterprise. On a campus, these efforts would have to be solidly grounded and consistent with the mission and goals of the institution. Although the processes may be similar in different institutions, care would have to be taken to preserve and respect diversity of institutional type and students served. Achieving true accountability would require a high degree of self-monitoring by mathematicians and mathematics educators.

Professional development activities could be undertaken as a joint effort among faculty to ensure that they have broad and sustained impact. Such activities might (even) include faculty from disciplines outside mathematics. For example, while experimenting with alternative instructional strategies, faculty can celebrate their successes and gain insights into problems they encounter by sharing their experiences with one another. Curriculum development could be a collaborative effort involving groups of faculty. This is especially important in mathematics because of the cumulative nature of the discipline, where changing the curriculum in one course can impact subsequent courses.

Option C: ***Support faculty throughout their professional careers as their areas of interest change.***

Accomplishments such as promotion and tenure can bring with them different responsibilities and obligations for faculty. In addition, individuals' interests can change many times during their professional careers. At these junctures, it is important that faculty think seriously about how they will allocate their time, energy, and other resources.

Similarly, it is important for institutional leaders to think about ways in which they can support faculty throughout their professional careers. Senior faculty want to feel that their work is valued and acknowledged regardless of the area in which it is done. For those faculty interested in moving into administrative lines, it would be helpful to create paths that allow such movement and make provisions for administrators who wish to return to the classroom. In return for this support, institutions need to know that they can rely on the institutional commitment of senior faculty who have experience and expertise and who know the institution, its mission and goals, and its students.

Option D: ***Create and support natural communities of interest.*** At present there are virtually no generally accepted methods in the mathematics community for assessing growth and effectiveness in teaching, although there have been some promising starts. The research community, in contrast, is the one sector of

higher education in which there is a well-established process of review. A widely accepted standard in the culture of the research community is that productivity and growth are measured by publication in peer-reviewed journals, the amount and type of outside grant support received, and recognition by peers as reflected in invitations to attend and present papers at conferences.

The existence of an accepted procedure for assessing productivity and growth in research is made possible, in part, by the fact that each sub-group of researchers--topologists, for instance--forms a naturally connected community. Members of these communities speak the same language and have a common set of standards for judging professional achievement and excellence. In these settings, peer review reflects that natural community of interest.

One example of a growing "natural community" in mathematics education is that of faculty involved in the calculus reform movement. The community developed as an outgrowth of a conference, *Toward a Lean and Lively Calculus*, held at Tulane University in 1986. Members of the community are in agreement that both curriculum and teaching methods for calculus need to be changed, although they are not in total agreement about what those changes should be. They have developed a common language related to calculus reform and attend meetings where they exchange ideas and materials.

Efforts to document growth in teaching, likewise, can be performed most readily within other similar natural communities. These communities may consist of faculty in similar types of institutions, in institutions that serve similar populations, or in institutions that have some other identifiable linkage. *Fostering natural communities of interest around educational issues can provide a context for peer review and a source for developing a common language for discussion and debate*. Professional organizations and faculty networks such as MER can contribute to this effort by nurturing natural communities of interest.

Some of the problems that exist in evaluating teaching can be resolved within these natural communities. The major problem is that teaching is generally a private activity that occurs within a classroom. Except for occasional observations of faculty for purposes of reappointment, promotion, or tenure, there is rarely another faculty member present in the classroom. Often the only feedback a faculty member receives on her or his teaching is the end-of-semester student evaluations. These evaluations are not generally highly regarded by faculty, who rarely have input into the development of the evaluation instrument and frequently are suspicious of how the results will be used by administrators.

To be evaluated, teaching must become a public activity. Frequent observations by colleagues, open discussion about pedagogical issues, and institutional and departmental recognition of the importance and validity of working on educationally significant problems are examples of steps that might be taken for teaching to be valued as highly as research. Work on educationally significant problems might include developing and revising curricula, identifying and promoting ways to preserve and address diversity among institutions in higher education, and helping the public understand changes in mathematics and its role in society [Parker, 1993].

PROVIDING TOOLS

Once faculty begin to appreciate the importance of valuing good teaching and to work on educationally significant problems, they need to have appropriate tools they can use to demonstrate their growth and effectiveness in the educational enterprise.

Issue #2: *What tools can faculty use to demonstrate their growth and effectiveness in undergraduate mathematics education?* Tools to assess growth and effectiveness in undergraduate mathematics education and to stimulate professional change are needed at two levels: individual and group (department, institution). For individuals, growth and effectiveness are currently assessed by self-, peer- and student- evaluations. The tool most often used for self-evaluation by individual faculty members is an expanded curriculum vita or professional brief; more recently faculty have begun to develop teaching portfolios. The major difference between professional briefs and teaching portfolios is that professional briefs provide a snapshot of what a faculty member has achieved, whereas teaching portfolios represent work in progress and are designed to show growth and change in addition to specific accomplishments.

Departments can develop "departmental portraits" that demonstrate how well they are achieving their goals and contributing to the progress toward accomplishing the institutional mission. Traditional tools for professional

development of groups of faculty include seminars and workshops on specific topics (either discipline-based or related to curriculum and pedagogy). Departments can also use case studies to stimulate discussion about problematic situations and their solutions.

Option A: *Professional Briefs*

Faculty often prepare professional briefs when applying for promotion, reappointment, or tenure. Their purpose is to provide a picture of what faculty members, in consultation with their department chair, feels represents their best work since the last official review. In addition to a curriculum vita listing educational background, publications and presentations, honors, grants, and service, professional briefs may include letters of recommendation from colleagues in one's field as well as student and peer evaluations of teaching. They may also contain a statement of professional goals.

Option B: *Teaching Portfolios*

Portfolios allow individuals to document their own change and growth in teaching over a period of years. They generally contain samples of course syllabi, examinations, student-, self- and peer-evaluations, examples of student work, descriptions of classroom-based research, and letters from graduates and colleagues. Portfolios may also track the progress of students taught by a particular faculty member through such indicators as grades in subsequent mathematics courses. Mentoring, participation in faculty and departmental seminars, and the use of new approaches (such as computers) to teaching may also become part of the record of professional growth [Edgerton, 1991].

Option C: *Departmental Portraits*

Assessment tools also can be developed on the departmental level. For example, departments can create "portraits" similar to individual teaching portfolios to determine how well they are meeting the goals of the mathematics program as well as supporting the mission and goals of the institution. They can also devise methods to determine specific areas in which individual department members can make significant contributions. It is critical that these designations be reviewed periodically to accommodate changes in interests among faculty members.

Departmental portraits can be used by deans and department heads to conduct meaningful reviews of broad educational programs and as background for periodic external departmental revenues. Institutions can use the reviews to set priorities and allocate resources in ways that reward departments that are successfully meeting their objectives.

Similarly, mathematics departments can use the guidelines developed by the MAA and AMATYC to assess their own standing. They could then develop "action plans" to bring themselves in line with the guidelines within a set time period.

Option D: *Case Studies*

The case method has a long history in fields such as business and law, and is now finding a niche in teaching. Cases studies are detailed, story-like accounts of classroom incidents designed to raise issues about effective teaching and learning. A well-designed case contains a core of ambiguity that engenders lively, sometimes passionate, discussion and debate. The purpose of case studies is not to give answers but to raise questions, to encourage problem-solving, and, ultimately, to promote more effective classroom practice. The problem-solving nature of case studies should make them especially appealing to mathematicians [Hutchings, 1991, 1993].

In addition to being used to examine the dynamics of the classroom, cases can be used to help faculty look at the responsibilities and behaviors of entire departments or institutions. They can also be used in faculty development groups designed to make teaching "public" and to extend the responsibilities of faculty members beyond the classroom.

Case studies are being developed by a number of organizations around the country. For example, the American Association of Higher Education is creating cases for use in a variety of disciplines. Similar work is underway at the Center for Case Studies in Education (part of the School of Education at Pace University in White Plains, New York). Although there are few current case studies that deal with problems specific to mathematics

education, there is considerable potential for the development of such materials.

ADDITIONAL FORUMS FOR FEEDBACK

From this short review, it is clear that state-of-the-art assessment of growth and effectiveness in teaching undergraduate mathematics falls short of the needs and goals of educational reform. Considerable dialogue and exploration is required to determine which of the options suggested above--or other possibilities not mentioned--are most effective in achieving the desired goals. Departments, institutions, and professional societies can help lead this exploration in several important ways.

We invite departments, institutions and professional societies to provide ongoing feedback. This might be accomplished on campuses through discussions about the Issues Paper at department or committee meetings, seminars or faculty development workshops. Professional societies can sponsor sessions, minicourses or workshops that focus on the issues contained in this paper. Please send comments and recommendations to: Susan Forman, Director of College & University Programs, Mathematical Sciences Education Board, 2101 Constitution Ave., NW, HA 476, Washington, DC 20418; FAX to Susan Forman at (202) 334- 1453; or e-mail to sforman@nas.edu.

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